

NATIONAL MISSILE DEFENSE (NMD) (GROUND-BASED MIDCOURSE DEFENSE)



The title of the National Missile Defense program has been formally changed to Ground-Based Midcourse Defense (GMD). The mission of the GMD system is to defend all 50 United States against a limited strike of Intercontinental-class Ballistic Missiles (ICBMs) by adversaries from rest-of-world, or *rogue* nations, with a residual capability against small-scale unauthorized or accidental launches from existing nuclear powers. The system must perform detection, discrimination, battle management, and intercept functions, which require the integration of multiple sensor, communications, command and control, and weapon systems.

The exact GMD configuration is evolving, as options for a deployable system are being considered and the role of sea- and space-based defense architectures is being defined. The GMD system of record is an integrated collection of subsystems, referred to as Elements, that perform dedicated functions during an ICBM engagement. The system will include a Battle Management, Command, Control, and Communications (BMC³) element, four types of long-range sensors (the Defense Support Program and Space Based Infrared System satellites, Upgraded Early Warning Radar (UEWR), and a Ground-based X Band Radar (XBR)) and an arsenal of Ground-based Interceptors (GBIs). The BMC³ will perform engagement planning and situation assessment while keeping a human-in-control, and serve to integrate the GBI and sensor operations through the In-Flight Interceptor Communications System (IFICS). The GBI is a silo-based, ICBM-class missile that delivers a Exoatmospheric Kill Vehicle (EKV) to a point above the atmosphere en route to engage a threat target cluster. After separation from the booster, the EKV flies to an intercept point provided prior to launch. In-flight communication events between the EKV and the ground provide updates on the intercept point and other parameters. After necessary diverts, the EKV activates infrared and visible sensors to acquire and track the target. The EKV uses its guidance, navigation and control functions, while employing its discrimination capability to identify and intercept the threat RV. After the intercept, ground- and space-based sensors continue to collect data so that a kill assessment can be made to evaluate the success or failure of the engagement.

BACKGROUND INFORMATION

The previous acquisition strategy for GMD culminated in the Deployment Readiness Review (DRR) on August 3, 2000. Neither testing nor modeling and simulation produced adequate results to support a deployment decision. As a result, on September 1, 2000, the President announced that, based

on the information available to him, he could not conclude that there was enough confidence in the technology and operational effectiveness of the entire GMD system to move forward to deployment. He also asked the Secretary of Defense to continue a robust program of development and testing.

The Ballistic Missile Defense Organization is in the process of revising its approach to ballistic missile defense. The distinction between National and Theater Missile Defense will be de-emphasized, as focus will be placed on different phases in the engagement process: boost phase, midcourse and terminal phase. The midcourse phase may also eventually incorporate sea-based components to kill incoming ICBMs. The system will be developed in block increments, with the first segment being termed the Initial Capability, which is unchanged from the old C1 program (a few RVs with simple countermeasures). Additionally, the program is modifying its development planning to adopt a *capability* vs. a *requirements* oriented approach. While the objective operational requirements are the ultimate goal, the utility of the incremental blocks will be assessed for possible deployment against emerging threats.

TEST & EVALUATION ACTIVITY

As the program redefines itself, test planning is in a similar state of flux. The existing TEMP is no longer an accurate representation of the GMD T&E program and needs to be updated. Several test planning initiatives (such as the Block 04/06 Testbed and the Expanded Testbed Plan-2) are scheduled for completion in late 1QFY02. These test planning initiatives are a result of DOT&E FY00 Annual Report recommendations and address the previously identified flight test constraints and operational realism concerns. The use of the Kodiak Launch Complex specifically addresses the need for Multiple Simultaneous Engagement testing. The next TEMP revision will begin upon completion of these efforts to incorporate the new test range capabilities.

GMD T&E will continue to leverage flight, ground and laboratory testing, modeling and simulation and User Exercises at the Joint National Integration Center to assess Human-In-Control functionality. In that regard, BMDO is considering expanding test range capabilities to address previously recognized inadequacies in the flight test program that include restricted engagement geometries, inadequate sensor coverage and limited operational realism. The expanded test range will integrate additional interceptor and target launch locations, midcourse radar installation, a mid-Pacific IFICS Data Terminal and multiple simultaneous engagement capabilities. The program plans to continue piggybacking on Minuteman operational evaluation launches that would carry a more varied and challenging target suite to examine discrimination issues. Ground Testing will continue at the Integrated Systems Test Capability (ISTC) and will expand to Boeing's new Prime Consolidated Integration Laboratory (PCIL). More advanced representations of the system elements will be used in the PCIL and ISTC. Hardware-In-The-Loop (HWIL) testing of the EKV is still limited and needs an aggressive approach to adequately test the discrimination and homing functions. EKV HWIL testing will begin in FY03 at the Arnold Engineering Development Facility.

Near-term GMD T&E planning focuses on demonstrating end-to-end integrated system performance. The principal functions to be demonstrated include target detection, acquisition, tracking, correlation, and handover, real-time discrimination, kill assessment, battle management and engagement planning, component integration and interface compatibility, human-in-control operations, interoperability with other national defense assets, and system lethality. The principal tools used to assess performance of these functions are flight tests, ground tests, and computer simulations. The key system simulation, the Lead System Integrator Integrated Distributed Simulation (LIDS), has continued

its slow evolution. A reduced scope LIDS Build 5 has been delivered to the government and its performance is being assessed.

FLIGHT TESTING

System elements will continue to be integrated and tested in a series of Integrated Flight Tests (IFTs). Initially, these tests necessarily relied heavily on the use of surrogates. As the system design matures, more prototypes are being introduced into the test architecture. However, some surrogates (including the interceptor booster and FPQ-14/C-band transponder for midcourse tracking) will continue to be needed for the next several tests until the tactical booster is proven out and until new tracking software is available.

Two GMD flight tests were conducted in FY01. IFT-6, was conducted on July 14, 2001 and IFT-7 was conducted on December 3, 2001. As replays of IFT-5 (with respect to engagement conditions and system configuration), both attempts successfully intercepted the target RVs and demonstrated end-to-end GMD system functionality with surrogate and prototype elements in a configuration representative of the system to be deployed. The only objective not satisfied in IFT-6 was real-time hit assessment by the GBR-P, which incorrectly reported a MISS. A software fix for this anomaly was implemented prior to IFT-7. Its performance is still being assessed as of the writing of this report. Prior to FY01, tests included a successful intercept in IFT-3 followed by two successive failures in IFT-4 & 5. IFT-1 & 2 were successful non-intercept fly-by tests.

GROUND TESTING

Integrated Ground Tests (IGTs) performed at the ISTC use a combination of models, software, and prototype hardware components to assess the deployable system in stressing environments and operational scenarios not achievable in actual flight tests. While the execution of the IGTs is improving through the addition of newer and more representative versions of GMD element software/hardware and improvement to the physical realism of the simulated environment, current IGT results need to be interpreted with caution. Since the designs of each of the GMD elements are not yet mature relative to the Initial Capability objectives, neither are their software/hardware representations in the ISTC. For example, the tactical booster design and performance parameters have not yet been defined, thus deployed booster performance during an engagement cannot be accurately modeled. Similarly, tactical discrimination algorithms for the EKV are still under development. Limitations in the ISTC test environment and the GBR-P simulation software necessitates thinning the number of threats and other objects from the design-to scenarios, resulting in a significant reduction in complexity for both XBR and EKV discrimination functions. Consequently, the GMD Prime Contractor is currently using the IGTs for integration purposes rather than to assess system performance. The OTAs, on the other hand, will still need to use them for limited performance assessments and will have to do so with the current limitations of the ISTC.

IGT-6 was the only IGT conducted in FY01. It demonstrated the successful integration of the BMC3, GBR-P/XBR and UEWB simulations and, for the first time, a GBI simulation. Five different threat scenarios were used in the runs-for-record, each of which incorporated only a single RV and limited debris. All scenarios were successfully executed. Despite their limitations, data collected during IGT-6 were beneficial and may have partially contributed to the success of IFT-6 since IGT data analysis identified some issues associated with the processing of In Flight Target Updates and infrared data on the simulated EKV. The ISTC will host IGTs through FY03. Its fidelity and complexity are expected to increase to provide a more operationally realistic environment to assess GMD functionality. After FY03, the Boeing PCIL will host ground tests similar to the IGTs.

Pre-mission and post-flight reconstruction testing were conducted at the ISTC for IFT-6. Pre-mission Test-6 provided risk reduction for the flight test by exercising the actual flight test software in both nominal and off-nominal scenarios.

LETHALITY TESTING

The Live Fire Test & Evaluation (LFT&E) Working Group, a subgroup of the GMD Lethality IPT, develops the LFT&E strategy for GMD. LFT&E activities will include flight testing, sub-scale light-gas-gun (LGG) testing, and simulation analyses. Sled tests could possibly be conducted to examine full-scale intercepts at the very low end of the intercept velocity range.

The GMD lethality evaluation effort has thus far concentrated on lethality test and analysis activities to support the development and accreditation of simulations. An initial series of quarter-scale LGG tests was successfully completed on December 7, 2000. Additional LGG testing is planned. The reduced scale LGG testing is a significant part of the evolving GMD LFT&E strategy. Its main objective is to generate lethality data to support validation of hydrocode predictions and to provide test bases for specifying modeling and simulation anchor points. For a given target and applicable intercept conditions, the anchor points define kill zones for prediction on GMD lethality. The earlier LGG test series generated lethality data against scaled targets for a specified impact velocity and a variety of hitpoints and strike angles. These tests also generated data to verify kill assessment instrumentation for LFT&E flight tests and supported development of kill assessment methodology. There were twelve Equations-of-State gas gun tests in FY01 to validate hydrocode developed in FY00. IFT-6 resulted in an intercept of the target. Lethality data collected during the test is being assessed by DOT&E.

TEST & EVALUATION ASSESSMENT

Despite the revised program, the schedule established for the GMD Program presents a major challenge. In spite of this, the program has tried to maintain an event rather than schedule driven focus in FY01.

Previous DOT&E Annual Reports to Congress identified a number of risks that could have significant impact on the GMD T&E program's ability to test, analyze, and evaluate system performance and to prepare for operational testing. The degree to which those risk areas have changed from the last reporting cycle are addressed below:

- Limited engagement conditions: As addressed above, the plan to develop an expanded test range will attempt to minimize the constraints to tactically realistic scenarios. Additionally, fielding an initial testbed configuration would enhance the capability to examine multiple engagement configurations.
- GBI booster testing: In order to increase the current Boost Vehicle (BV) burnout velocity margin for the most stressing engagement scenarios, a redirected BV program has initiated a competition for a higher performance Alternate BV (ABV). A down select to two ABV designs, that may, or may not, include a variant of the current BV design, is planned for November 2001. First use of the ABV in an IFT has been scheduled for IFT-16 in February 2004.

- Limitations of ground testing: The ISTC currently provides a venue for testing element integration and limited system performance assessments via the IGTs. Program schedules show the current ISTC activities ending in FY03. After FY03, Integrated Mission Tests (IMTs) will be conducted at the PCIL, a Boeing facility that promises an advanced *plug and play* integrated HWIL simulation capability requiring no modifications to element software or hardware. The PCIL is intended to be an integration tool, not a tool for performance assessment. If the PCIL is not suitable for performance assessment, the issue of how LIDS would be anchored arises, since flight testing will never be able to reproduce the intensity of the required design-to scenarios. This would leave a non-validated LIDS as the only system-level performance assessment tool.
- Target suite: IFT-6 still relied on a large balloon as the sole decoy. This is appropriate for early developmental testing to exercise basic discrimination functions, but flight tests need to start incorporating decoys that more closely match the target RV. Test targets of the current program do not represent the complete *design-to* threat space and are not representative of the full spectrum of sensor discrimination requirements. Much of this limitation, however, is attributable to the lack of information surrounding the real threat. As the knowledge of the threat evolves, the risk in this area should decrease slightly.
- Multiple target testing: The program has intends to conduct multiple simultaneous engagements prior to completion of the flight tests under contract with Boeing. Since a new TEMP has not been produced, this decision is not yet formally documented nor funded.
- Spare test articles: The previous TEMP identified a lack of spare test articles due to a resource allocation trade-off. Current program planning uses a rolling spare concept in which the test target for the next test flight serves as the backup for the current flight test. This approach will mitigate the spare target problem; however, spare test articles are still recommended for the interceptor and EKV, where test failures could have major schedule impacts.
- Limitations of ground lethality testing: Currently, ground lethality test data has to be collected from light-gas-gun tests of reduced-scale (1:4) replicas of EKV surrogates and targets. These gas gun tests are conducted at the lower-end (six kilometers per second or less) of the intercept velocity spectrum and are used to validate hydrocode computer simulations for analysis of the higher velocity tactical collisions. There is no ground test facility capable of propelling EKV's or their full-scale replicas against targets at the closing velocities expected for GMD intercepts. These closing velocities will exceed 7 kilometers per second (KPS) and in some cases will even exceed 10 KPS. Existing full-scale sled track facilities have only approached 3 KPS. However, while limited, these facilities still provide the ability to conduct testing of full-scale components.
- Modeling & Simulation. Modeling and simulation (M&S) efforts have been reoriented. The current BMDO plan calls for the M&S maturity to evolve consistent with the incremental block development of the system rather than with advanced planning and analysis. Specifically, key functionalities such as discrimination performance (both radar and IR) against more advanced decoys and countermeasures, engagement planning performance against more complex threats, integration of SBIRS/Low, and overall system performance and architecture suitability to meet an objective threat level cannot be predicted. Focusing M&S development in support of incremental block development significantly reduces the near-term software and incremental block development risks but substantially increases the ability to predict ultimate system performance.

LESSONS LEARNED

DOT&E wishes to reemphasize two particular areas from its report to the DRR:

- Several factors drive the need for a focused hardware-in-the-loop approach in parallel with the flight test program. They include the risk of a flight test failure for a myriad of reasons, the difficulty in deploying adequate and realistic flight countermeasures in a flight test and speculation on the EKV's ability to discriminate countermeasures. DOT&E strongly recommends the JPO continue its effort to develop a flexible, comprehensive hardware-in-the-loop facility, which can present a high fidelity representation of the threat target for designing and testing of the EKV.
- As noted above, flight tests still rely on surrogate elements. The most significant of these surrogates the FPQ-14 radar whose data are needed to produce the critical Weapon Task Plan that contains the initial engagement parameters for the interceptor. Use of this radar obviously degrades test realism. Furthermore, since the FPQ-14 tracks a transponder on the target, program critics can allege that the tests are rigged through the use of a *beacon*. DOT&E strongly supports the placement of an X-Band Radar in a mid-course test vicinity to increase both the realism and variety of test geometries that can be created.